

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problem Mailbox.**

microelectronic fabrication

New Laser-Directed Deposition Technology

This new direct-write process draws midsize electronic features without masks and resists.

By Doyle Miller

Today, two very different technologies dominate microelectronic fabrication: thick-film processes and thin-film processes. In thick-film processes, screen printing is used to apply patterns to substrates. Electronic components are created by successive applications of materials, followed by firing at temperatures up to 1,000°C.

Although it is simple and relatively inexpensive, thick-film technology has some disadvantages. First, it requires high temperatures that would damage flexible polymer substrates. Second, screen printing usually cannot produce lines and spaces smaller than 100 μm .

To produce smaller features, manufacturers normally use thin-film processes that pattern materials using masks and photoresists. Although it's complicated and costly, thin-film technology can produce complex devices with sub-micron features.

These two established microelectronic fabrication techniques do a good job of depositing relatively large and very small electronic features. But what about medium-sized features from 1 to 100 μm wide, such as resistors, capacitors and inductors? Currently, no deposition technology on the market is aimed at these midsize structures.

To fill this gap in electronics manufacturing, the U.S. Defense Advanced

Research Projects Agency (DARPA) is spending \$40 million to create new technologies that will produce "meso-scale" features. In fact, one DARPA contractor has already developed a new process specifically to produce midsize electronic features. This direct-write process can deposit electronic materials onto substrates without masks, thick-film equipment or other photolithographic accessories.

Simpler and less expensive than thin-film techniques, the direct-write process can lay down lines less than 10 μm wide. In this process, metal and ceramic precursor particles flow into the path of a focused laser beam. The laser then sinters the materials to produce the best electrical and mechanical properties. By concentrating high temperatures on the deposited materials rather than on the substrate, laser sintering lets manufacturers use low-cost polymer substrates that cannot withstand high-temperature oven firing.

Direct-write is done using a compact multicomponent tool. An in-line conveyor system moves substrates into the tool's work area, where a frequency-doubled continuous-wave Nd:YAG laser deposits and sinters the electronic materials. Deposition control is handled by an X, Y, Z overhead gantry driven by three-axis, brushless servo motors. Other electronic manufacturing processes include many steps between the creation of CAD drawings and the start of production. But the maskless direct-write process lets manufacturers move right from "art to part."

A flexible technology, direct-write can deposit a wide variety of materials, including metals, conductors, insulators, ferrites and polymers. Deposits can be made on virtually any surface material — silicon, glass, plastics, metals and ceramics — and on both high- and low-temperature substrates.

On a typical PWB, most of the space is taken up by surface-mount resistors, capacitors and inductors. But direct-write can embed these components into the board. By eliminating surface-mount components and reducing interconnect pitch and line widths, direct-write can reduce PWB size by up to 70 percent.

Other applications for direct-write include bond-pad redistribution, rework of electronic circuitry and custom bump fabrication for flip-chip interconnects. In flex circuit manufacturing, direct-write can precisely deposit metal on non-conformal substrates. The direct-write tool can place very small amounts of material exactly where they need to be.

Doyle Miller is vice president of micro-fabrication with Optomec Inc., Albuquerque, NM, (505) 761-8250, e-mail: dmiller@optomec.com.